Title: Substrates for printing

Field of Invention

This invention concerns substrates, primarily papers and in particular to a method of modifying the substrate to make it suitable for use in printing security documents.

Background to the invention

It is known to scan a printed document and convert the image into digital data for feeding into a computer. A copy of the original document can be printed out using the digital image data using a laser jet or inkjet printer, and in this situation, the imaging device (usually a scanner), computer and printer, acts like a copier. The stored data can be edited or manipulated using graphics software so that the final print can be a very accurate reproduction of the original. Furthermore, the data can be transmitted for example via the internet or by modem and telephone line to a remote location, or stored for future use on a disk or other memory device, and this technology can be used to counterfeit security documents such as cheques, banknotes, identity documents and the like.

Prior art

Methods are known for modifying substrates so that genuine substrates can be identified and distinguished from counterfeit substrates. Typically these methods include marking the genuine substrate with materials which fluoresce under ultra-violet, or which only emit light at some special region of the visible spectrum, or involve the addition of special material such as magnetic materials or infra-red absorbing pigments, or the inclusion of large scale water marking in pictorial or bar code form on or in the substrate. All these methods require either a gross alteration of the substrate (as in watermarking methods) or the inclusion of special materials usually requiring special detectors to determine if the substrate of any document is genuine. Such methods tend to be expensive, the effects are

usually readily visible to the naked eye, and it is not impossible to modify paper and other substrates in a similar manner, so as to confuse a verification process.

Object of the invention

It is one object of the present invention to provide a special substrate on which security documents can be printed, having features which will not be reproduced by a photocopier but which can be detected using a computer or other data processor based image system. However, the features will not normally be reproduced by a copier or printer supplied with image data signals obtained from an unprotected such system, as it can be arranged that if the computer system or copier detects the said features it can therefore refuse to process the image.

Summary of the invention

According to one aspect of the present invention a substrate on which a security document is to be printed includes a plurality of physical features in the surface thereof which when illuminated and imaged produce image data signals in the output of a photoelectric device characterised in that:

1. the contrast between the features and the remainder of the substrate surface is selected so that image data signals corresponding to the features are substantially indistinguishable from image data signals relating to the remainder of the substrate surface and/or from background noise signals in the output of the photoelectric device and are thereby indistinguishable by eye; and

2. the features are repeated at intervals over at least some of the surface area of the substrate, whereby time or position of signals relating to each feature will bear at least one fixed relationship to signals relating to other of said features, whereby a computing device supplied with the image data signals can be programmed to identify whether feature signals bearing the said at least one fixed relationship are present in the data, to assist in identifying the imaged document.

The features may be repeated at regular intervals.

Each of the physical features may be similar in character to each of the other features in the said surface.

Documents of the same type may be printed on substrate bearing similar features having a similar fixed relationship over the surface of the substrate. Thus for example bank notes of one denomination may be printed on a substrate having surface features of a particular type and one or more particular spacings.

The spacing may be selected so as to be constant in one direction only or varied according to a special, known pattern.

A similar or different regular spacing may be selected for features in another direction bearing a particular spacial relationship relative to the first said direction, for example perpendicular to the said first direction.

In a preferred example the features are arranged in a 2D matrix in the substrate surface.

The existence of such features in a substrate surface constitutes a primary encoding of the substrate allowing substrates to be distinguished from substrates not containing said features, or to be distinguished one from another depending on the choice of features.

Secondary encoding of a substrate may be achieved by introducing a variation into the matrix such as by omitting features from particular positions in such a regular matrix.

Thus for example every fourth feature along each third line may be omitted.

Preferably security documents are encoded using both primary and secondary encodings.

In addition or alternatively secondary encoding may be provided if the matrix is formed from features having two distinctive characteristic and, instead of omitting features at

specific positions within the matrix, features of one type are located at one set of positions in the matrix, and features of the other type are located at other positions in the matrix. Thus in a simple example one set of features may be generally circular in shape, whereas interspersed features producing a secondary encoding may have a different readily distinguishable shape such as rectangular or triangular.

Since the encoding of a substrate can be achieved by selecting the spacing between features or selecting features having a specific characteristic such as shape which can be identified in image data signals relating thereto, and/or by the substitution of features having a first characteristic at selected points in a regularly occurring matrix of such features by other features having a second different characteristic, and/or the omission of features at particular points in a matrix, there is an almost infinite number of possible combinations and permutations available to encode security document substrates.

Therefore not only does the invention permit a reliable method for identification of security documents, so as to readily detect forgeries which are not printed on an appropriate substrate, but each individual type of security document such as banknotes of different denominations, cheques originating from different banks, passports issued by different offices, and the like, if desired can be uniquely identified by a particular primary and/or secondary encoding selected for the substrate on which they are to be printed.

Image analysis techniques for identifying the presence of regularly occurring patterns and/or drop-outs within regularly occurring patterns and/or shape(s) or other visibly distinguishable features of detectable features in an image, are readily available and known, and by using high speed processors such as DSPs and the like, image data can be checked and verified or otherwise, virtually instantaneously as documents are scanned.

Preferably a physical feature is selected for encoding the surface of a substrate to provide a primary encoding, which will not appear in the electrostatic image of a photocopier. This ensures that attempts to reproduce the original by photocopying will merely produce a copy containing the printed content of the document unless the substrate onto which it is copied contains the correct physical encoding in the surface thereof.

More preferably, if a secondary encoding is present, any variation in the primary encoding which constitutes the secondary encoding is even less capable of being distinguished by the naked eye or picked up by a photosensitive device as used in a photocopier.

Preferably the physical feature encoding is in the form of a repeat pattern.

As the identification features are such that the appearance of the security document (for example a bank note) is not affected or disturbed aesthetically, since in the case of banknotes, the introduction of new notes provided on substrate according to the invention is permissable alongside existing banknotes printed on unencoded substrate, since if the general appearance of the documents is unchanged to the naked eye, old but nevertheless authentic notes which do not contain the physical feature encoding on the substrate surface provided by the invention, will appear similar to banknotes printed on encoded substrate.

Examples of physical feature encoding of a substrate as aforesaid comprise, embossing with inkless intaglio or embossing the surface by calendaring during manufacture of the substrate.

Two or more different encoding techniques may be combined in any substrate.

The invention also lies in impressing in the surface of a substrate onto which a security document is to be printed indentations and/or grooves in accordance with a first pattern which contains encoded therein a second pattern, to enable a security document printed on such a substrate to be identified by subjecting image data signals obtained from scanning the document to an appropriate mathematical algorithm to determine whether the second pattern can be found in image data signals relating to the first pattern.

A pattern may be encoded to produce multiple iterations of a code on the substrate.

The encoded pattern may not extend over the whole of the surface of the substrate forming each document but only over selected areas which align with particular printed areas of the substrate, and according to another aspect of the invention, the printed areas are

selected so as to enhance the detection of the substrate surface variation during scanning and conversion of the image into image data signals.

Redundancy created by multiple iterations can be used to advantage since the large number of similar iterations enhances the detectability of the code by increasing the effective signal to noise ratio. This in combination with the selection of particular regions of the printed areas of the final document in which to locate the iterations, facilitates the detection by a data processor of the presence of an otherwise substantially invisible pattern in the data signals derived from the scanning.

For a document identification system to work, the encoding of the documents must be capable of being read for example by optically scanning the documents and generating image data signals which can be handled by a computer, or by using a specialist imaging and image analysing apparatus performing this function.

The invention also lies in a security document substrate adapted to be identifiable as such by having detectable surface features therein features to enable identification as aforesaid.

The invention also lies in a security document when printed on a substrate as aforesaid.

A primary application of the invention lies in treating the surface of a substrate as aforesaid for use in the production of security documents so as to inhibit or degrade the reproduction of such security documents using a scanning process which converts the image into image data signals for controlling a printing process, in which a second control is introduced if surface encoding is detected by subjecting the image data signals to an appropriate algorithm, which second control serves to downgrade or inhibit the printing process so as to prevent the reproduction of the original document, or of a good quality reproduction thereof.

A second application of the invention lies in a document verification method by scanning the document and converting the optical information into electrical signals using a photosensitive device and in which for recognition purposes, a data processor is

programmed to look for one or more surface encoding, information in the electrical signals which if detected in image data obtained from imaging and scanning the document, will generate a confirmation signal, validating the document, and vice versa.

The invention thus also provides a computer based document scanning device which can be used to validate a document by checking that one or more patterns of one or more particular features are present in the document.

Thus for example bank note authentication devices can be provided at relatively low cost to be associated with tills in shops, banks and post offices, so that at transaction points bank notes tendered by the public can be verified before they are accepted.

In the case of a currency note, it may be of further interest to determine what denomination it is, and if more than one originating organisation is involved, it may also be advantageous to determine which organisation issued the note. Computer based document checking facilities of this type can be used as note accepters, can be used in note exchangers, and can be used to enable blind persons to discover what bank notes they have in their possession.

Description of different encoding techniques

The surface treatment of a substrate in accordance with the invention includes any technique which results in lighter and darker regions to be visible in the surface of a treated sheet of substrate when illuminated for scanning.

Either or both primary and secondary encodings may be in the form of repeat pattern which are distinguishable under appropriate illumination to provide detectable content in digital signals obtained by scanning.

(1) Embossing

In a first technique embodying the invention, the substrate may be embossed during its

manufacture. Thus it is customary in paper or sheet plastics manufacture to make the material smooth enough for printing by passing it through a high pressure nip between two steel rollers, a process known as calendaring. By forming one or both of these rollers with indentations, a paper or plastics substrate forced therebetween, will be formed with an embossing pattern corresponding to the indentations. By suitably encoding the embossed features, the substrate will be encoded as required by the invention, and can be detected by suitable illumination and converted into digital data signals by a scanner for analysis by a data processor.

(2) Surface treatment of lacquered papers

Where a paper or plastics substrate material has mixed therewith a resin or lacquer or other material to provide a smooth surface for printing, an encoded structure can be formed in the surface such that the actual surface of the substrate is sufficiently smooth to accept printing ink to enable a security document to be printed thereon, but at the same time contains a fine pattern of less smooth regions, which may be less receptive of printing ink.

(3) Impregnation

The surface may also be modified by a technique in which selected regions of a substrate describe a repeat pattern by being impregnated with a fluid such as a resin, or lacquer, such that the optical absorbtion or reflectance characteristics or optical density of the substrate is altered sufficiently as between impregnated and non-impregnated areas as to be discernable under incident light as during scanning for digitising.

(4) Laser treatment

The surface of the substrate can be etched by a laser beam, so as to produce cavities or grooves in the surface to be printed (or awaiting printing). This technique lends itself to the production of very fine patterns in the surface of the substrate and since a laser beam can be modulated very accurately can be used to introduce depth modulation in any such

grooves or cavities as well as or instead of edge or thickness of spacing modulation.

(5) Watermarking

Watermarks alter the thickness and/or texture of a substrate, which variations and/or can be rendered visible under incident light and can be used to form primary and/or secondary encoding of the invention. They may be formed in two ways.

In the Fourdrinier paper making method, the wet paper is embossed using an embossing roller as it is being formed, thereby impacting a mark in the paper corresponding to the embossing. By forming the embossing in a suitable repeat pattern which extends over the area of the web, so the paper can be encoded with the watermark pattern.

A second technique for forming a watermark uses the so-called cylinder-mould method. In this method the watermark is formed by a cylindrical wire mesh on which is impressed "mouldings" in the form of images. During manufacture of the paper, fibres build up to a greater or lesser extent on the mesh moundings and where the thickness of the paper is greater, this gives a darker effect when viewed in transmission than do regions which are thinner and therefore which appear lighter when viewed in transmission. However where either types of watermark is just visible in incident light this can be used to provide the background coding required by the invention.

In accordance with the invention either watermarking technique may be employed to apply a pattern in the surface of a substrate especially a paper substrate, which is virtually imperceptible to the naked eye, but which will appear as a low contrast pattern when subjected to incident light as where a document is arranged for scanning and digitising.

The techniques so far described provide a surface encoded substrate which subsequently can be printed to form a security document. However some of the encoding techniques, eg embossing, may be applied after some or all of the printing of the document has occurred.

For example embossing may be applied after a title, or other text, or personal data for example in the case of an ID document has been printed onto a plain substrate, and a surface encoding formed as a post-printing step.

Encoding by embossing can be achieved whilst printing at least some regions of a document. Thus the surface encoding may be imparted to the document by so-called "blind" intaglio printing, or intaglio printing with colourless ink. In such a method an image is printed using a plate containing engraved areas, some of which are filled with ink and some of which are left empty in the case of blind intaglio printing. The engraved plate, inked as appropriate, is pressed under high pressure against the substrate so as to cause the ink to transfer to the substrate. The substrate can become embossed with the engraved image, under the pressure applied, with parts of the substrate surface being printed, and others merely embossed.

Description of Drawings

In the accompanying drawings:-

Figure 1 shows a banknote substrate physically formed with barcode features in practice not discernable to the naked eye;

Figure 2 shows a banknote image printed over the substrate;

Figure 3 is a flow chart of the process for embossing the barcode features on the substrate;

Figures 4 and 5 show images of the banknote revealed by a computer code extraction routine; and

Figure 6 is a flow chart of one possible detection routine.

Description of Embodiment

Production

The process for physically forming in this case embossing, identification features on a banknote (or other security document) substrate will be clear from Figure 3 without further description.

The resulting substrate is shown in Figure 1, except that in practice the identification features, in this case a repetitive barcode pattern, would be invisible to the naked eye.

The banknote is conventionally printed over the substrate and the result is shown in Figure 4.

Since in practice the identification features are invisible to the naked eye, they are not aesthetically disturbing and do not affect the freedom of design of the banknote image. It is to be noted that the banknote design may be printed either before or after the identification features physically formed in this case by embossing (Figure 3).

Detection

There are various ways that computer based equipment can detect the aforesaid identification features and two such methods are described hereinafter.

The encoded document when scanned into a computer, is converted to a digital format. This typically means that the image is analysed into red, green and blue channels for each picture element or pixel. The colour of the picture element is assigned a value in each of these channels on a scale from 0 to 255 (8 bits) typically such that a full intensity is assigned to the value 255 and 'no colour' the value 0. Thus, bright white will be represented by all three channels having the value 255 and black by a zero intensity having the value 0.

When a real image, such as that of the printed banknote is scanned into the system, most of the pixel values will lie in a central region between, say, 230 for the paper background and 40 for the darkest print. The pixels relating to the embossed encoding will be affected by the shadowing from the embossing caused by the lighting in the detection device. They will generally be within a band close to the paper background values.

Assume, for example, that the embossing is shallow so that the shadows are weak and mainly within a band of 20 grey scale values relative to that of the paper background.

It is a simple matter for a computer program to reset all values between a value just below that of the paper (in this example, 228) and the bottom of the values relating to the encoding band (in this example say, 210) to a value of 10, or even zero (near black) and to reset all other values between 210 and 0 in this example to 230 (in other words the same colour as the paper background).

This procedure has the effect of eliminating all the printed design features but not the encoding and those very weak features associated with the design, which are usually very few in number since they cannot be easily seen and would not therefore be included in the design for aesthetic reasons. The embossed encoding itself would by this procedure now be rendered black (see Figure 5) so that it can be read by a program especially designed to recognise the coding. As a simple sample, if the coding were a series of Alphanumeric characters such as letters and numbers, an optical character recognition program could be used to read the data and determine if it was likely to be a known code. Alternatively, more sophisticated image detection techniques could be used, especially if the coding were of a more complex type such as that used in digital watermarking for example. In some cases, it may be preferred in order to show the encoding only (Figure 6).

Alternatively, the embossed encoding could be extracted using a contrast enhancement routine such as is commonly known as 'equalisation'. This is shown in Figure 7. This type of routine sets the maximum value of the pixels in each channel to 255 and the minimum value to 0 and then attempts to smoothly redistribute the intervening pixel values between the two. This has the effect of increasing the difference between the pixel values

close to the paper background and thus those relating to the code so that they are easier to recognise in an image recognition program or routine. This method has the disadvantage that other design features unrelated to the code are still present and need to be disregarded by the recognition routine.

However, more sophisticated routines, can be used which recognise complex encoding patterns such as those used for high-level codes in complex images and patterns.